UCRL-JC-124509 Abs

The Impact of Beam Smoothing Method on Direct Drive Target Performance for the National Ignition Facility

Joshua E. Rothenberg and Stephen V. Weber

Lawrence Livermore National Laboratory, L-439

P. O. Box 808, Livermore, CA 94551

Telephone: (510) 423-8613 FAX: (510) 422-5537

Email: JR1 @ LLNL.GOV

ORAL PRESENTATION PREFERRED

ABSTRACT

The laser uniformity requirements for the successful implementation of direct drive inertial confinement fusion are significantly different from those for indirect drive. Direct drive requires a highly uniform illumination pattern on the target in order to minimize imprinted perturbations which are then amplified by Rayleigh-Taylor instability growth. The various approaches to this uniformity requirement all make use of target illumination with a time varying speckle pattern.[1-5] The imprint of the high spatial frequencies from speckle onto the target is ameliorated by the averaging of multiple uncorrelated speckle patterns over some effective integration time. The requirement on laser uniformity to achieve target ignition is then thought to be roughly stated in terms of requiring the aggregate normalized RMS variance of the time integrated intensity σ to be less than ~1%. Calculations have shown that by using the two-dimensional smoothing by spectral dispersion method (SSD)[4,5] in conjunction with the overlap of the 192 beams and orthogonal polarizations proposed for

the National Ignition Facility, this uniformity level can be achieved in a few hundred picoseconds. However, given the complicated nature of the target physics hydrodynamics, it is clear that a more detailed analysis is necessary.

We have evaluated the hydrodynamic performance of direct drive targets in terms of the l-mode spectrum imprinted as a result of a given beam smoothing method. It is shown that the choice of beam smoothing method can significantly alter this spectrum. The imprint and ensuing hydrodynamics are calculated using an analytic model based on extensive numerical simulations of the target physics. The results of modeling of the implosion hydrodynamics at both peak velocity and ignition will be presented. It is found that low spatial frequencies (l-modes of 30-200) play a dominant role and that the beam smoothing method should therefore be optimized accordingly. Two classes of beam smoothing methods (SSD, and Induced Spatial Incoherence -- ISI[1,3]) will be discussed and compared in this context. In addition, the modeling indicates that nonlinear saturation of Rayleigh-Taylor growth plays a major role in target performance. The impact of the choice of beam smoothing method on the hydrodynamics in the nonlinear regime will also be presented.

This work was performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

References

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